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Jet Multiplicity in $W \to l\nu$ at $\sqrt{s} = 1.8$ TeV $p\bar{p}$ Collisions

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JET MULTIPLICITY IN $W \to l\nu$ AT $\sqrt{s} = 1.8$ TeV $p\bar{p}$ COLLISIONS

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ABSTRACT

An analysis of the $W \to l\nu$ events, $l = e, \mu$, yields a jet multiplicity distribution. Data selection and background are presented. The data are shown to be in good agreement with the VECBOS Monte Carlo which generates $W \to l\nu$ plus n jets by a leading order QCD calculation ($n = 0 \div 4$).

1. Introduction

Processes containing W bosons accompanied by jets constitute a benchmark for tests of QCD and their understanding is relevant to the study of many new physics processes. W + multijets events represent in fact a leading source of background to processes like top pairs or supersymmetric particles. In the last years, a lot of effort has been put on developing techniques to calculate W + multijets processes. Recently, a leading order calculation of W + 0,1,2,3,4 jets has been made available and turned into VECBOS, a matrix element Monte Carlo[1].

We present the observed jet activity associated to W production, and report details on data selections and jet counting as well as the study of the background to the W events. The jet multiplicity distribution is compared with QCD predictions after full detector simulation.

2. Data Selection

The $W \to l\nu$ candidates, $l = e, \mu$, used in this analysis are selected from data samples of lepton-triggered events. The W candidates samples are derived imposing very strict high-P_T lepton identification criteria[2], we report here the kinematic cuts relevant to the W tagging. The electron identification is restricted to the central calorimeter to insure high quality, $|\eta| \leq 1.1$. Both leptons, detected within a fiducial volume, are required to be isolated and to have a E_T (or P_T for muons) larger than 20 GeV. The identification efficiency is estimated to be $\epsilon_e = 0.84 \pm 0.03$ for electrons and $\epsilon_\mu = 90.4 \pm 3.8\%$ for muons. Finally to select W candidates a missing tranverse energy, $\not{E}_t$ defined within $|\eta| \leq 3.6$, larger than 20 GeV/c was required.

2.1. Jets

Jets are observed in the CDF calorimeter and identified by the CDF cluster-

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ing algorith[3]. The main feature of this algorithm is that it defines a cone in η-ϕ space with radius R. The energy and momenta of all the calorimeter towers within the cone are summed to give a single four-vector for each jet. The jets accompanying the W are required to satisfy the cuts $|\eta_{jet}| \leq 2.4$ and measured $E_t^{jet} \geq 15.0$ GeV/c in a cone of $R = 0.7$.

We have estimated the uncertainty in jet counting by taking into account uncertainties in the jet energy scale (single pion and electron response, fragmentation and fluctuation of the underlying event energy falling within the clustering cone), detector jet energy resolution and finally from the non-uniform η detector response to jets due to cracks between detectors.

3. Background studies

Background to the W samples is mainly contributed by non-signal bosons and by QCD. The various background sources have been already reported in previous studies[4].

The non-signal bosons background is independent of the associated jet production and is mainly due to τ leptonic decay in $W \to \tau\nu$. W events generated with the Isajet Monte Carlo and with full detector simulation has been used to determine the acceptance of this sequential τ decay. To obtain the percentage of background in the sample we have normalized the Monte Carlo events to the W event sample after subtraction of the rest of the background sources considered.

QCD and Heavy Quark production can also mimic our signal. For the QCD case, when one of the partons fragmenting into an electromagnetic rich jet is identified as and electron (or stiff track, for muons) and the other parton mimics a neutrino through fluctuation in fragmentation and/or measurements. Given the high rates of QCD production this rare situation can contribute to our selected sample. The production of Heavy Flavour with real leptons from semileptonic decay of the quark is the other source of background.

We have estimated this background as a function of the jet multiplicity using a sample of central leptons which satisfied all the lepton selection criteria but the lepton isolation one. The method[5] is based on the expected/observed non correlation between lepton isolation and missing transverse energy. Table 1 shows the global background for the electron and muon samples.

	0 jets	1 jets	2 jets	3 jets	4 jets
Electron	$7.3 \pm 0.8\%$	$11.9 \pm 1.7\%$	$12.5 \pm 4.1\%$	$7.6 \pm 5.0\%$	$7.6 \pm 5.0\%$
Muon	$16.3 \pm 1.5\%$	$16.7 \pm 4.5\%$	$19.7 \pm 4.5\%$	$15.3 \pm 5.1\%$	$15.3 \pm 5.1\%$

Table 1: Background for the different Jet Multiplicities in the Electron and Muon sample.

4. Jet Multiplicity Distributions

We have studied individual kinematical variables of the W + n jets events and compared with QCD Monte Carlo events after full detector simulation, in all the cases we found a reasonable good agreement within our present statistics. The small statistics for high jet multiplicity prevents us from making significant comparisons of event topology.

Figure 1 shows the jet multiplicity distributions for both electron and muon data before background subtraction. The entries in each multiplicity bin is normalized to the total number of events in the sample. Errors on the data are only statistical. The figure shows the good agreement in the shape of the multiplicity distribution between the two data samples. The Monte Carlo prediction for $Q^2 = m_W^2$ is also shown.

Figure 2 shows the total number of events in the (a) electron and (b) muon samples after statistical background subtraction versus the number of reconstructed jets in the event. As mentioned before jet counting is done for $E_t^{jet} \geq 15$ GeV. In the figures the data are compared with absolute Monte Carlo prediction for the two Q^2 values: $Q^2 = m_W^2$ and $Q^2 =< P_t >^2$. In all the figures the errors in the data account for statistical and systematical uncertainties.

The errors on the Monte Carlo prediction account for the uncertainty in the luminosity, the theoretical uncertainty estimated from different choices of structure functions and finally the statistical uncertainty in the Monte Carlo samples. The $Q^2 = m_W^2$ scale seems to reproduce more accurately the low jet multiplicity bins. The behaviour of both Q^2 scales as function of the jet multiplicity are compatible within two standard deviations for electron and muon Monte Carlo samples.

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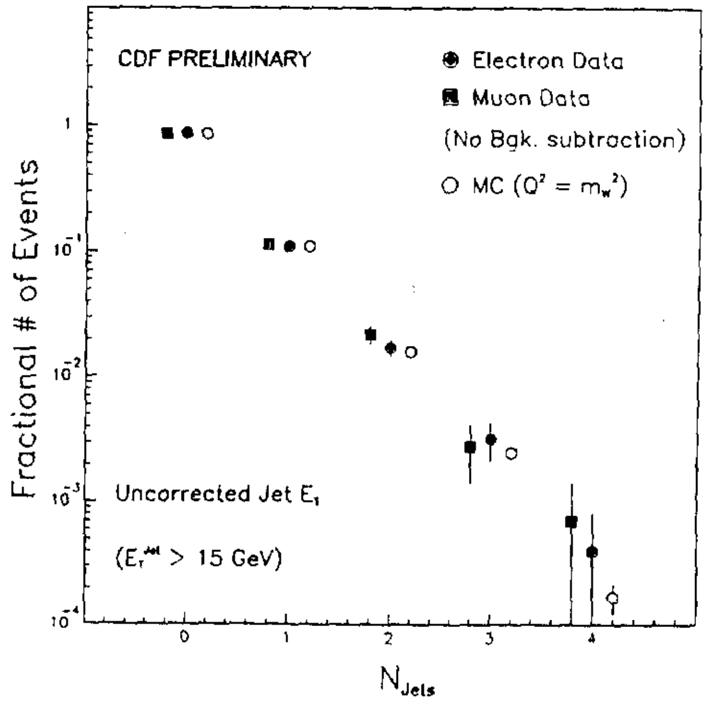

Figure 1: Jet multiplicity distributions for both electron and muon data normalized to the total number of events.

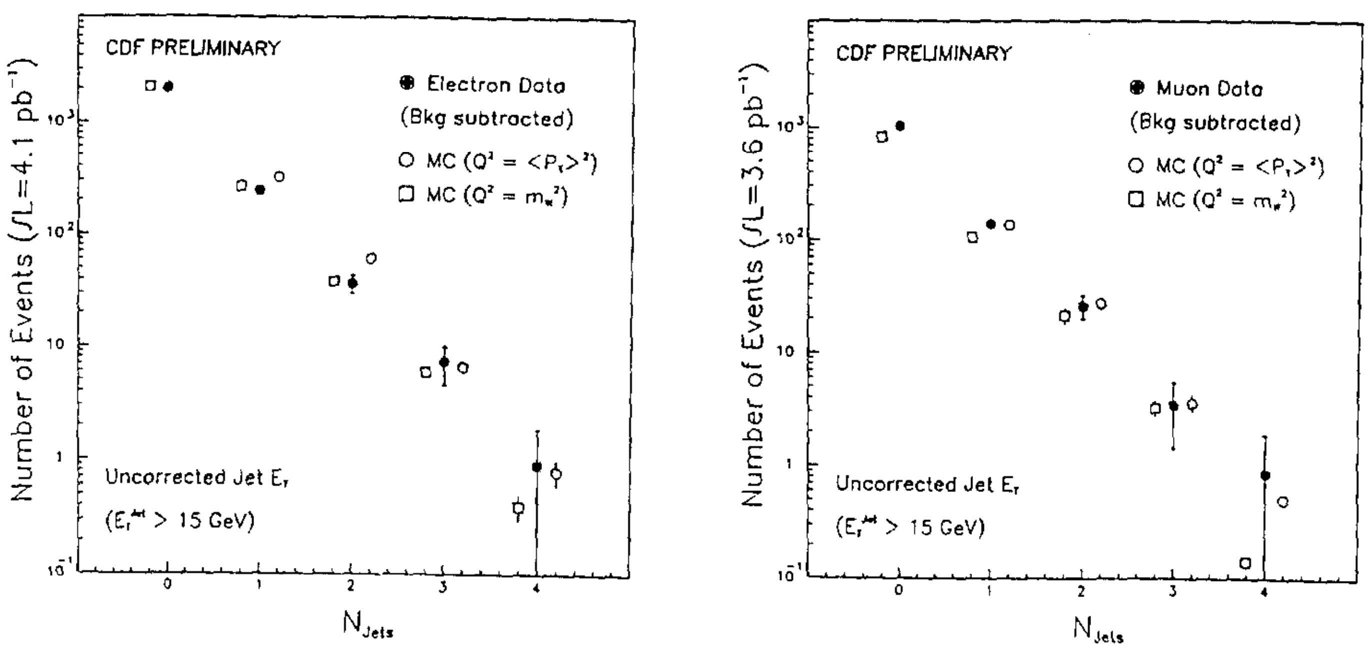

Figure 2: Total number of events in the (a) electron and (b) muon samples compared with absolute Monte Carlo prediction.